CLAIMS:

What is claimed is:

1. A folded dipole having a dipole axis and a pair of arms which together have a profile which is concave on one side and convex on the other when viewed along the dipole axis.

2. A folded dipole according to claim 1 wherein the arms are at least partially curved.

3. A folded dipole according to claim 2 wherein the arms have curved portions which have a substantially constant radius of curvature.

4. A folded dipole according to claim 2 wherein the arms are at least partially curved in a plane substantially orthogonal to the dipole axis.

5. A folded dipole according to claim 1 wherein the pair of arms meet at a corner.

6. A folded dipole according to claim 5 wherein the corner subtends an angle lying in the range of 80° to 100°.

7. A folded dipole according to claim 5 wherein each arm is substantially straight.

8. A folded dipole according to claim 5 wherein the corner is truncated.

9. A folded dipole according to claim 1 further comprising an input section coupled to a concave side of the pair of arms.

10. A folded dipole according to claim 1 wherein the pair of arms are formed of sheet material.

11. A folded dipole according to claim 10 wherein both arms are formed from the same sheet.

12. A folded dipole according to claim 1 further comprising a first feed leg coupled to one of the arms and a second feed leg coupled to the other arm.

13. An antenna comprising a ground plane; and a folded dipole according to claim 1 arranged with its dipole axis directed away from the ground plane.

14. A base station including an antenna according to claim 13.

15. A communication system including a network of base stations according to claim 14.

16. A dipole box comprising two or more folded dipoles arranged around a central region, each folded dipole having a dipole axis and a pair of arms which together have a profile which is concave on one side and convex on the other when viewed in plan perpendicular to the central region.

17. A dipole box according to claim 16 wherein each pair of arms has a curved portion with a centre of curvature which is located in the central region.

18. A dipole box according to claim 16 comprising four or more folded dipoles arranged around the central region.

19. A dipole box according to claim 18 wherein the dipoles are arranged as orthogonally opposed pairs.

20. A dipole box according to claim 19 wherein each pair of dipoles is oriented at about ±45° with respect to vertical.

21. An antenna comprising a ground plane; and a dipole box according to claim 16 arranged with the dipole axes directed away from the ground plane.

22. An antenna according to claim 21 comprising two or more dipole boxes spaced apart along an antenna axis, each dipole box comprising four dipoles oriented at about ±45° with respect to the antenna axis.

23. An antenna according to claim 21 wherein the dipole boxes are operable over a low frequency range, and the antenna further comprises one or more columns of high frequency radiating elements superimposed with the dipole boxes and operable over a high frequency range having a mid point higher than a mid point of the low frequency range.

24. An antenna according to claim 23 wherein the high frequency radiating elements are cross dipoles.

25. An antenna according to claim 21 comprising two or more dipole boxes arranged along an antenna axis, each dipole box comprising a pair of substantially semicircular folded dipoles.

26. A base station including an antenna according to claim 21.

27. A communication system including a network of base stations according to claim 26.

28. A method of manufacturing a folded dipole having a dipole axis and a pair of arms which together have a profile which is concave on one side and convex on the other when viewed along the dipole axis, the method comprising forming the pair of arms from a sheet of conductive material.

29. A method according to claim 28 wherein the arms are formed by stamping the arms out from the sheet.

30. A method according to claim 28 further comprising forming one or more feed legs from the sheet.

31. A method according to claim 30 further comprising bending the feed leg(s) out of

the plane of the sheet.

32. An electrically insulating retaining element for retaining together adjacent ends of a pair of dipoles, the element comprising a frame formed by an opposed pair of side walls and an opposed pair of end walls; a dividing wall joining the opposed pair of side walls; and a pair of projections each provided on a respective end wall and directed inwardly towards the dividing wall.

33. An element according to claim 32 wherein the projections are folded tabs.

34. An element according to claim 32 wherein the opposed pair of side walls includes a convex outer wall and a concave inner wall.

35. An electrically insulating retaining element for retaining together adjacent ends of a pair of dipoles, the element comprising a body portion having a pair of sockets on opposite side of the body portion; and a pair of resilient members which each obstruct a respective socket and resiliently flex, when in use, to admit an end of a dipole into the socket.

36. An electrically insulating retaining element according to claim 35 wherein the resilient members comprise arms which extend outwardly from a proximal end attached to the body portion to a distal end which is formed with an inwardly directed shoulder.

37. An electrically insulating retaining element according to claim 35, wherein the sockets are configured to receive an end of a dipole as a snap fit.

38. A dipole assembly comprising two or more dipoles having adjacent ends retained together by electrically insulating retaining elements.

39. An assembly according to claim 38 wherein the dipoles are arranged end to end so as to enclose a central region.

40. An assembly according to claim 38 wherein the dipoles are folded dipoles, and wherein the adjacent ends have proximal inner edges which are engaged by the retaining element(s) to secure the dipoles in place.

41. An assembly according to claim 38 wherein the or each retaining element is a retaining element according to claim 32.

42. An assembly according to claim 41 wherein the dipoles are folded dipoles, and wherein the adjacent ends have proximal inner edges which are each engaged by a respective projection to secure the dipoles in place.

43. An assembly according to claim 38 wherein the or each retaining element is a retaining element according to claim 35.

44. An assembly according to claim 44, wherein the dipole ends are received in the sockets as a snap fit.

45. An antenna comprising a ground plane; and a dipole assembly according to claim 38.

46. A base station including an antenna according to claim 45.

47. A communication system including a network of base stations according to claim 46.

48. An antenna comprising:

a first module comprising an outer box of two or more dipoles arranged around a first central region, and an inner box of two or more dipoles located in the first central region concentrically with the outer box; and

a second module comprising an outer box of two or more dipoles arranged around a second central region which is spaced from the first region, and an inner box of two or more dipoles located in the second central region concentrically with the outer box.

49. An antenna according to claim 48 wherein each inner box is operable over a high frequency range and each outer box is operable over a low frequency range having a mid point lower than a mid point of the high frequency range.

50. An antenna according to claim 49 further comprising an additional high frequency dipole box operable in the high frequency range and positioned in a gap between the first and second modules whereby the spacing between the high frequency boxes is smaller than the spacing between the low frequency boxes.

51. An antenna according to claim 48 further comprising a ground plane.

52. An antenna according claim 48 wherein the outer box dipoles comprise folded dipoles.

53. An antenna according to claim 48 wherein the inner box dipoles comprise folded dipoles.

54. An antenna according to claim 48 wherein the outer box dipoles each have a dipole axis and a pair of arms which together have a profile which is concave on one side and convex on the other when viewed along the dipole axis

55. An antenna according to claim 48 wherein the inner box dipoles comprise folded dipoles having a dipole axis and a pair of arms which together have a profile which is concave on one side and convex on the other when viewed along the dipole axis.

56. An antenna according to claim 48 wherein the outer box dipoles are arranged in a linear array.

57. An antenna according to claim 48 wherein each outer box comprises orthogonally opposing pairs of dipoles.

58. An antenna according to claim 48 wherein each inner box comprises orthogonally

opposing pairs of dipoles.

59. An antenna according to claim 57 wherein each pair of dipoles in the outer box is off-set with respect to vertical by about ± 45°.

60. An antenna according to claim 58 wherein each pair of dipoles in the inner box is off-set with respect to vertical by about ± 45°.

61. An antenna according to claim 48 wherein the outer box dipoles comprise two orthogonally opposed pairs of folded dipoles off-set with respect to vertical by about ± 45°which each have a dipole axis and a pair of arms which together have a profile which is concave on one side and convex on the other when viewed along the dipole axis; and the inner box dipoles comprise two orthogonally opposed pairs of folded dipoles off-set with respect to vertical by about ± 45° having a dipole axis and a pair of arms which together have a profile which is concave on one side and convex on the other when viewed along the dipole axis.

62. An antenna according to claim 61 wherein the arms of the inner and outer box dipoles are curved.

63. An antenna according to claim 61 wherein the arms of the inner and outer box dipoles are straight.

64. An antenna according to claim 61 wherein the arms of the outer box dipoles are curved and the arms of the inner box dipoles are straight.

65. An antenna according to claim 61 wherein the arms of the outer box dipoles are straight and the arms of the inner box dipoles are curved.

66. An antenna according to claim 48 wherein the outer box dipoles comprise two orthogonally opposed pairs of folded dipoles off-set with respect to vertical by about ± 45°which each have a dipole axis and a pair of arms which together have a profile which is concave on one side and convex on the other when viewed along the dipole axis; and the inner box dipoles comprise two orthogonally opposed pairs of folded dipoles off-set with respect to vertical by about ± 45° in a diamond-shaped configuration.

67. An antenna according to claim 66 wherein the arms of the outer box dipoles are curved.

68. An antenna according to claim 66 wherein the arms of the outer box dipoles are straight.

69. An antenna according to claim 48 wherein the outer box dipoles comprise two orthogonally opposed pairs of folded dipoles off-set with respect to vertical by about ± 45° in a diamond-shaped configuration; and the inner box dipoles comprise two orthogonally opposed pairs of folded dipoles off-set with respect to vertical by about ± 45° which each have a dipole axis and a pair of arms which together have a profile which is concave on one side and convex on the other when viewed along the dipole axis.

70. An antenna according to claim 69 wherein the arms of the inner box dipoles are curved.

71. An antenna according to claim 69 wherein the arms of the inner box dipoles are straight.

72. A base station including an antenna according to claim 48.

73. A communication system including a network of base stations according to claim 72.

74. A dual polarized folded dipole antenna comprising:

a first unit configured for transmitting and/or receiving signals in a first polarization direction; and

a second unit configured for transmitting and/or receiving signals in a second polarization direction different to the first polarization direction,

wherein each unit includes a conductor having a feed section, a radiator input section, and at least one radiating section integrally formed with the radiator input section and the feed section, the radiating section including first and second ends, a fed dipole and a passive dipole, the fed dipole being connected to the radiator input section, the passive dipole

being disposed in spaced relation to the fed dipole to form a gap, the passive dipole being shorted to the fed dipole at the first and second ends.

75. A dual polarized folded dipole antenna according to claim 74 wherein the feed section is a microstrip feed section having an adjacent ground plane on one side only.

76. A dual polarized folded dipole antenna according to claim 75 further comprising a ground plane, wherein the feed section is an air suspended feed section separated from the ground plane by an air gap.

77. A dual polarized folded dipole antenna according to claim 74 wherein the antenna comprises a slant polarized antenna with two or more modules arranged along an antenna axis, wherein the first and second polarization directions are at an angle to the antenna axis.

78. A dual polarized folded dipole antenna according to claim 74 wherein the first unit includes a first pair of folded dipoles, the second unit includes a second pair of folded dipoles, each folded dipole including a respective radiator input section and a respective radiating section, and wherein the two pairs of radiating sections are arranged in a box configuration around a central region.

79. A dual polarized folded dipole antenna according to claim 78 wherein the box configuration is a ring configuration.

80. A dual polarized folded dipole antenna according to claim 78 wherein the box configuration is a square configuration.

81. A dual polarized folded dipole antenna according to claim 74 further comprising a ground plane, wherein the radiating sections extend substantially parallel with the ground plane.

82. A dual polarized folded dipole antenna according to claim 74 further comprising a ground plane, wherein the radiator input section includes a pair of feed legs which each extend substantially transversely to the ground plane.

83. A dual polarized folded dipole antenna according to claim 74 wherein the radiator input section includes a balun transformer.

84. A dual polarized folded dipole antenna according to claim 74 wherein the radiator input section includes a splitter, first and second feedlines which meet said feed section at said splitter so as to complete a closed loop including the first and second feedlines and the radiating section, and a phase delay element for introducing a phase difference between the first and second feedlines.

85. A base station including a dual polarized folded dipole antenna according to claim 74.

86. A communication system including a network of base stations according to claim 85.

87. A folded dipole antenna comprising:

a ground plane

a conductor having a feed section extending adjacent the ground plane and spaced therefrom by a dielectric, a radiator input section, and at least one radiating section integrally formed with the radiator input section and the feed section, the radiating section including first and second ends, a fed dipole and a passive dipole, the fed dipole being connected to the radiator input section, the passive dipole being disposed in spaced relation to the fed dipole to form a gap, the passive dipole being shorted to the fed dipole at the first and second ends,

wherein the feed section is a microstrip feed section having an adjacent ground plane on one side only, and

wherein the radiator input section includes a balun transformer.

88. A folded dipole antenna according to claim 87 wherein the feed section is an air suspended feed section separated from the ground plane by an air gap.

89. A folded dipole antenna comprising:

a ground plane

a conductor having a feed section extending adjacent the ground plane and spaced therefrom by a dielectric, a radiator input section, and at least one radiating section integrally formed with the radiator input section and the feed section, the radiating section including first and second ends, a fed dipole and a passive dipole, the fed dipole being connected to the radiator input section, the passive dipole being disposed in spaced relation to the fed dipole to form a gap, the passive dipole being shorted to the fed dipole at the first and second ends,

wherein the feed section is a microstrip feed section having an adjacent ground plane on one side only, and

wherein the radiator input section includes a splitter, first and second feedlines which meet said feed section at said splitter so as to complete a closed loop including the first and second feedlines and the radiating section, and a phase delay element for introducing a phase difference between the first and second feedlines.

90. A folded dipole antenna according to claim 89 wherein the feed section is an air suspended feed section separated from the ground plane by an air gap.

91. A base station including a folded dipole antenna according to claim 87.

92. A communication system including a network of base stations according to claim 91.

93. A coaxial to microstrip transition comprising:

a ground plane;

a microstrip transmission line on a first side of the ground plane;

a coaxial transmission line on a second side of the ground plane opposite to the first side of the ground plane, the coaxial transmission line having a central conductor coupled to the microstrip line, a coaxial cylindrical conductor sleeve coupled to the ground plane, and a dielectric material between the central conductor and the sleeve,

a conductive ground transition body in conductive engagement with the sleeve; and

a ground locking member applying a force to the ground transition body so as to force the ground transition body into conductive engagement with the ground plane.

94. A coaxial to microstrip transition according to claim 93 wherein the microstrip transition line is an air suspended transition line separated from the ground plane by an air gap.

95. A coaxial to microstrip transition according to claim 93 wherein the ground transition body has a cylindrical inner bore in conductive engagement with the sleeve, and an outwardly extending flange which engages the ground locking member.

96. A coaxial to microstrip transition according to claim 93 wherein the central conductor passes through a hole in the ground plane, and wherein the flange has a chamfered surface which engages the ground locking member and generates a centering force which centers the central conductor with respect to the hole in the ground plane.

97. A coaxial to microstrip transition comprising:

a ground plane;

a microstrip transmission line on a first side of the ground plane;

a coaxial transmission line on a second side of the ground plane opposite to the first side of the ground plane, the coaxial transmission line having a central conductor coupled to the microstrip line, a coaxial

cylindrical conductor sleeve coupled to the ground plane, and a dielectric material between the central conductor and the sleeve,

a conductive line transition body in conductive engagement with the central conductor; and

a line locking member applying a force to the line transition body so as to force the line transition body into conductive engagement with the microstrip line.

98. A coaxial to microstrip transition according to claim 97 wherein the line transition body has a relatively narrow shaft passing through a hole in the microstrip transmission line, a relatively wide base, and a shoulder between the relatively narrow shaft and the relatively wide base, the shoulder being forced into conductive engagement with the microstrip line.

99. A coaxial to microstrip transition according to claim 98 wherein the line transition body has a cylindrical inner bore in conductive engagement with the central conductor.

100. A coaxial to microstrip transition according to claim 97 wherein the line transition body has an externally threaded shaft which passes through a hole in the microstrip transmission line, and the line locking member has an internally threaded bore which engages the externally threaded shaft.

101. A coaxial to microstrip transition according to claim 97 wherein the microstrip transition line is an air suspended transition line separated from the ground plane by an air gap.

102. An antenna including a coaxial to microstrip transition according to claim 93.

103. A base station including an antenna according to claim 102.

104. A communication system including a network of base stations according to claim 103.

105. A method of constructing a coaxial to microstrip transition, the method comprising:

arranging a microstrip transmission line on a first side of a ground plane;

arranging a coaxial transmission line on a second side of the ground plane opposite to the first side of the ground plane, the coaxial transmission line having a central conductor coupled to the microstrip line, a coaxial cylindrical conductor sleeve coupled to the ground plane, and a dielectric material between the central conductor and the sleeve,

arranging a conductive ground transition body in conductive engagement with the sleeve; and

applying a force to the ground transition body so as to force the ground transition body into conductive engagement with the ground plane.

106. A method of constructing a coaxial to microstrip transition, the method comprising:

arranging a microstrip transmission line on a first side of a ground plane;

arranging a coaxial transmission line on a second side of the ground plane opposite to the first side of the ground plane, the coaxial transmission line having a central conductor coupled to the microstrip line, a coaxial cylindrical conductor sleeve coupled to the ground plane, and a dielectric material between the central conductor and the sleeve,

arranging a conductive line transition body in conductive engagement with the central conductor; and

applying a force to the line transition body so as to force the line transition body into conductive engagement with the microstrip line.